Copy 1 of 6

P R O P O S A L

RADAR MAPPING SET

AAN-40037-C
Revision 1

Air Arm Division
Westinghouse Electric Corporation
Friendship International Airport
Baltimore, Maryland

TABLE OF CONTENTS

Filed in separate folder entitled "Equine - Spare Parts Contract 7 L-3011"

1. SCOPE

This proposal describes a high resolution, single channel side-looking radar equipment and related items in response to request for quotation. The equipment and services to be supplied are:

Item 1 - Four (4) Single Channel Radar Mapping Sets in accordance with Appendix A of this Proposal.

Item 2 - One (1) Set Maintenance Tools and Test Equipment.

Item 3 - One (1) Set Spare Parts for Items 1 and 2.

Item 4 - Two (2) Receiver-Transmitters.

2. GENERAL INFORMATION

The proposed Radar Mapping equipment will consist of the following units:

1 - Dual 15 ft. linear array antenna

1 - RF-Head

1 - Modulator

1 - Adapter Box

1 - Power Supply

1 - Recorder Unit

1 - Control Panel

1 - Alignment Panel

1 - Monitor Indicator

1 - Pressurizing Kit

1 - Set of Interconnecting Plugs and Adapters

The Dual antenna will be similar in construction to the present AN/APQ-56 (XA-2) antenna but with a 15 foot aperture. The receiver-transmitter will be a 100 KW unit. The power supply and recorder will incorporate such features as separation of A-scope and control panel from the main recorder package, drift compensation, provisions for automatic data inputs, continuous film motion and single channel recorder operation. A pressurization system consistent with the 100 KW peak power output will be provided.

The equipment, defined by the specification dated 12/9/55, Appendix A, is intended primarily for use in very high altitude aircraft. The proposed design is motivated by (a) this intended high-altitude application, (b) requirement for a relatively short delivery schedule, (c) a desire to evolve an equipment which embodies the packaging, performance, and quality features described in WCLR-301 to the greatest extent consistent with (a), (b), and (d) minimum weight.

Design of the equipment will be such that a minimum amount of the pilot's attention will be required during flight. A minimum amount of adjustment procedure will be required since the control complement will be equivalent to that required for a single sided system. AFC and automatic level control of the recorder settings will contribute to the automaticity of the radar operation.

Only one receiver-transmitter (RF-head and modulator) will be required per system. The two sections of the dual antenna will be alternately connected to the receiver-transmitter by a suitable switching arrangement. A recorder of new design will be required to display the receiver-transmitter video output on a single cathode-ray tube. The traces will be separated optically to provide the two images corresponding to the left and right target areas and will be photographically recorded on a moving strip film.

Handbooks of maintenance and operating instructions will be supplied.

3. DETAILED DESCRIPTION

3.1 Antenna

Each equipment will require one Dual Antenna. Each Dual Antenna will consist of two end-fed linear arrays having a 15-foot by 5-inch aperture. It will be similar in mechanical construction to the 10-foot extruded antenna design for the AN/APQ-56 (XA-2) equipment and will have similar electrical performance except for a narrower horizontal beamwidth. One Dual Antenna assembly will provide two beams, each looking to one side of the aircraft.

The horizontal beamwidth at the one-way half-power level will be approximately 0.13°. This narrow beamwidth is considered necessary to provide adequate azimuth resolution at the maximum line-of-sight range of 18 miles. The mid-frequency skew (degrees off normal to antenna longitudinal axis) will be approximately 2°. All horizontal side lobes will be at least -12 db in power from the main lobe. This pattern will be generated by a plane-mounted waveguide containing a row of about 800 dipole-equivalent slots each properly phased and powered.

An ideal vertical pattern would be so shaped that equal signals would be received from identical area targets at any ground range from zero to maximum. The vertical pattern will be shaped to approximate theideal within $\pm$ 1.5 db one way from an altitude of 70,000 feet over a ground range from 15 to 2 miles. A design goal will be to extend coverage to zero miles. The weight of each Dual Antenna assembly will be approximately 100 pounds.

3.2 Receiver-Transmitter

There are four basic methods of incorporating R/T units into a dual side looking radar system. These methods are as follows:

a) Two complete and independent R/T units may be used with each unit connected to its associated antenna. This method provides for the maximum magnetron power utilization, since the full power from two magnetrons is available.

   This method, however, is not considered to be the most suitable for a fighter reconnaissance aircraft because of the severe weight penalty of two R/T units and an added weight penalty in the power supply and recorder units.

b) Two magnetrons and two sets of receivers may be operated from a common modulator and power supply and packaged as a unit. This method is similar from a system viewpoint to that of (a) above and allows a small weight saving compared to two separate R/T units. This method still requires additional weight in the power supply and recorder units.

c) The transmitter power from one R/T unit may be divided to feed both sides of the system, and two receiving and recorder channels used with suitable directional coupler schemes to receive separated returns from the two sides. This system is somewhat lighter than the systems of (a) and (b) above, but is somewhat complex from a receiving standpoint, is inferior from a signal to noise ratio consideration compared with the other three possible methods, and does not allow a maximum weight reduction in the recorder and power supply.

d) The recommended method of incorporating an R/T unit into a dual side looking system involves the use of one R/T unit, alternately switched from one antenna to the other.

This method is the lightest and most straightforward of all four systems, allows weight savings in the recorder design, since basically one recorder channel can be switched from side to side synchronously with the R/T. (See detailed description of Recorder Systems, Section 3.3)

The use of this method, as compared with two separate R/T units, reduces system performance by something less than 3 db and probably less than 2 db. However, it appears that most of this system performance can be regained by the use of isolators and increased magnetron coupling described later in this section.

This small reduction of system performance, if magnetron power increases are not realizable, is not considered important in the application, and it is felt that the weight saving features of this method are very attractive for fighter type aircraft usage.

The receiver-transmitter will be a 100 KW RT unit similar to that designed for the AN/APQ-56 (XA-2), except the altitude limitation will be extended to 70,000 feet, an adapter box will be furnished to allow operation with the recorder, power supply and antennas described in this proposal, and an R F switch will alternately feed the two sections of the dual antenna.

Because the 100 KW magnetron size is relatively large, the receiver-transmitter will consist of two units which are referred to as the R.F. Head and the Modulator.

3.2.1 Modulator

The pressurized modulator unit will contain the modulator, klystron, klystron high voltage supply, AFC control circuitry and the post amplifier. Both top and bottom of this unit will be removable to allow ready access to the components.

An AFC circuit different from the AN/APQ-56 (XA-2) design may be required to keep the klystron properly tuned. In a system containing a waveguide switch the AFC problem is relatively difficult since it must be able to compensate for rapid impedance changes in the R-F lines caused by switching. The isolator on the magnetron output will reduce the pulling (frequency shift) of the magnetron due to these impedance changes and make the AFC circuitry less critical.

Each modulator will weight approximately 75 lbs. and occupy 1.75 cu. ft.

3.2.2 R. F. Head

The R. F. Head will consist of two compartments, one pressurized and one unpressurized. The pressurized compartment will contain the magnetron cathode stem, the pulse transformer, magnetron filament transformer and a blower to cool the magnetron stem. The unpressurized compartment will contain the duplexer, preamplifier and AFC IF strip.

The power output of the magnetron will be approximately 100 KW peak, as determined by the magnetron rating. Power output of the equipment will be somewhat less than this due to losses in the duplexer, waveguide and R. F. switch. In the APQ-56 (XA-2) RT unit duplexer and waveguide losses are about 1.4 db. It is expected that the losses in this unit will be comparable; this will be determined experimentally later in the program.

An isolator in the output of the magnetron will minimize changes in impedance caused by R-F switching and the effect of such changes upon the magnetron and AFC operation. In addition, it may be possible to relax the pulling requirement on the magnetron thus permitting the tube manufacturer to increase the coupling to the cavities and thereby increasing the output power.

The R. F. Head will weigh approximately 75 lbs. and occupy 1.4 cu. ft.

3.2.3 Pressurizing Kit

RG-96/U waveguide will not handle the power generated by the

100 KW magnetron without pressurization.

To permit this high power operation the antenna and coupling waveguide to the magnetron must be pressurized to a minimum of about 50 psia. This high pressure plus the larger volume of low pressure air required in the modulator and R. F. Head will be supplied by a pressurizing system which requires an input source of 5 psia minimum.

The pressurizing kit will weigh approximately 23 lbs. and occupy 0.5 cu. ft.

3.2.4. Adapter Box

It will be necessary to supply an additional unit which will contain relays and other minor components which were included in the APQ-56 (XA-2) power supply but which are not included in the power supply described in this proposal.

The adaptor box will weigh approximately 10 lbs. and occupy .25 cu. ft.

3.3 Recording System

The recording system proposed herein will be a major redesign of the AN/APQ-56 (XA-2) unit although many circuits will be very similar to their present counterparts. The end product will have been designed with MIL specification requirements as design objectives, and to meet the requirements of the specification, Appendix A. It will be noted that the sum of the improvements over the (XA-2) equipment will yield (a) a more flexible packaging configuration,

(b) a film record which is superior in ease of evaluation, precision, dynamic range, and total number of resolvable elements, (c) a weight reduction and (d) simplicity of operation.

The following paragraphs describe the proposed recording system:

The proposed recorder design is motivated by two factors, namely (a) maximum simplicity of operation as dictated by the requirements for minimum weight and minimum attention during flight and (b) maximum performance as required for successful automatic high-resolution mapping.

a) Simplicity

This recorder is to be used with a time-shared receiver-transmitter. Hence, at any instant, only a single-channel system will be required; i.e., one transmitter, one antenna, one receiver, one video amplifier, one display cathode-ray tube, one CRT deflection system, and one recording camera. During alternate time intervals signal energy will be switched from one antenna to another to permit mapping of the area on both sides of the aircraft. To record the received signals it will be necessary to switch from one film area to another film area in synchronism with the antenna switching. It will not be necessary to duplicate any of the components of a single-channel system ennumerated above except for antennas (2 required) and film areas (2 required) and provision for synchronous switching of these elements. Duplication of any of the other elements would be totally incompatable with the basic requirement for maximum simplicity, would increase weight, would decrease reliability, and would aggravate the alignment and performance monitoring problems.

In line with the foregoing basic philosophy, Westinghouse proposes a single-channel recorder with one essential exception - there will be a dual optical system to form two adjacent images of the CRT display with a shutter, operating in synchronism with the antenna switching, to produce alternate exposure of these two images. The result will be a recorder suitable for use with a two-side time-shared system but requiring only a single set of alignment and operating controls.

b) Performance

Experience has shown the absolute necessity for stable maximum performance if high-quality mapping is to be achieved. Insofar as the recorder is concerned, the most critical performance factors are resolution, distortion, and transfer characteristic (the relationship between film density and received signal strength). Resolution is limited primarily by the cathode-ray tube. It is important, therefore (1) to use the best possible CRT and (2) to use the longest possible trace consistent with tube dimensions. This latter consideration rules out such expedients as creating range sweeps right and left of a line through the center of the CRT screen for right and left mapping. The single CRT in the proposed recorder will utilize the full screen resolution capability for each side rather than divide this resolution between both sides.

Low-distortion mapping is achieved by use of ground range sweeps, compensation for antenna beam forward-looking angle, compensation for aircraft drift resulting from wind, and accurate use of ground speed information. All of these features will be included in proposed recorder.

Proper design and control of the relationship between film density and received signal strength is as important in terms of information content of the final film record as any other single factor in an automatic side looking system. The factors which affect this transfer characteristic include output vs. input voltage characteristic of the receiver (i-f and video amplifiers), brightness vs. bias of the CRT, and film "gamma". Of equal importance are the various level settings such as CRT bias, receiver gain, video limit level, and camera aperture. Careful control of these design parameters and operating conditions will be a basic and important part of the proposed recorder.

3.3.1 Packaging, General

The recording system will be built in four units, namely a recorder unit, a monitor indicator, a control panel, and an alignment panel. Estimated volumes and weights are as follows:

Recorder Unit	-	75 lbs.,	2.5 cu. ft.
Control Panel	-	17 lbs.,	0.25 cu. ft.
Alignment Panel	-	4 lbs.,	0.1 cu. ft.
Monitor Indicator	-	7 lbs.,	0.25 cu. ft.

3.3.2 Recorder Unit

The recorder unit will contain the following subassemblies or functions: camera, magazine with film drive and film velocity control, one intensity-modulated cathode-ray tube, deflection yoke, regulated high-voltage power supply, regulated focus supply, photometer, video amplifier, drift integrator, range mark generator, altitude delay circuit, hyperbolic sweep generator, and deflection driver.

The various components will be readily removable subassemblies in a common housing which, in turn, will be rigidly constructed and mounted on effective vibration isolaters to prevent loss of resolution as a result of aircraft vibration. The film magazine will be easily accessible for removal to facilitate ground handling. A focusing magnifier and ground glass reticle for aligning the images during pre-flight will be provided.

3.3.2.1 Camera and Magazine

The optics section of the recording camera will contain two lenses and reflecting mirrors or prisms to produce two adjacent reversed images of the cathode-ray tube intensity-modulated trace.

A flicker shutter will be provided in the image space immediately behind the lenses. This shutter will be a disc with an equal number of open and closed sectors alternately dispersed around a line which passes through the centers of both optical paths. The turning rate and length of each sector will be such that each individual optical path will be active for about 40% of the time at a recurrence rate in the neighborhood of 60 per second. (The requirement for this switching rate is derived as follows: at 1000 knots the aircraft travels 100 ft. or one resolveable element, in .06 sec. To prevent appreciable loss of resolution due to switching there should be at least 3 "looks" per resolveable element, i.e., .02 sec. maximum switching period.) The shutter will be driven by a synchro or other suitable device in synchronism with the R-F switch. The CRT trace will be blanked during the switching transition interval.

The optics section of the camera also will contain a motor-driven aperture control or equivalent to maintain constant exposure over the 250 to 1000 knot ground speed range, and facilities to permit pre-flight alignment and focusing of the CRT trace.

The proposed recorder will use continuously moving 5-inch film to provide ground track scanning. There are several advantages of continuous film travel compared to the frame-by-frame technique which has been employed in the APQ-56 (XA-2). For example, with continuous film travel:

(1) Interpretation, evaluation, and distance measurement is considerably easier for photographic interpretation Personnel.

(2) Map precision is increased by elimination of a major component of distortion created by CRT scan.

(3) Range resolution in the recorder is improved since it is possible to use a longer trace on the CRT.

(4) Size, weight, and support complexity of mirrors and prisms in camera periscope may be reduced materially.

(5) Attainable image contrast is increased since the magazine aperture may be narrowed to a slit.

(6) Violent film transport transients do not occur.

Alternately, however,

(1) Extreme film transport smoothness is required. No camera has ever been produced which completely satisfies this requirement, and

(2) Only one line is excited on the face of the CRT which accelerates phosphor aging.

It is noted, however, that current USAF and British developments have come close to satisfying the transport requirements with virtual breadboard models. Westinghouse has discussed this problem with a number of reputable precision intrument manufacturers in the past months, and, on the basis of these discussions, has let a sub-contract for development of this type of camera under contract AF-33(600)30545. The second deterrent (above) is not serious since the CRT beam currents used in side-looking recorders are low, about one microampere average in the APQ-56 (XA-2)

A data chamber will be imaged on the edge of the film at 15-mile intervals of ground distance. Heading, time, a counter, and a data card will be recorded. (The counter visible to the operator will be advanced in synchronism with the data recording.)

The film transport speed mechanism will be built for control by either the remote manual ground speed control or by tie-in with a doppler system such as the APN-81 or APN-79.

A film emulsion such as Linagraph Survey will be used. The important desired characteristics include high resolution, moderate gamma (near unity), large linear density range, and blue sensitivity.

The basic film record geometry will correspond approximately to Figure 1.

3.3.2.2 Cathode-Ray Tube

A single high resolution cathode-ray tube will be used, such as the DuMont type K1393 PAXM. This tube has a nominal spot size of .003 inch and a 4.25 inch useful face. To permit drift compensation

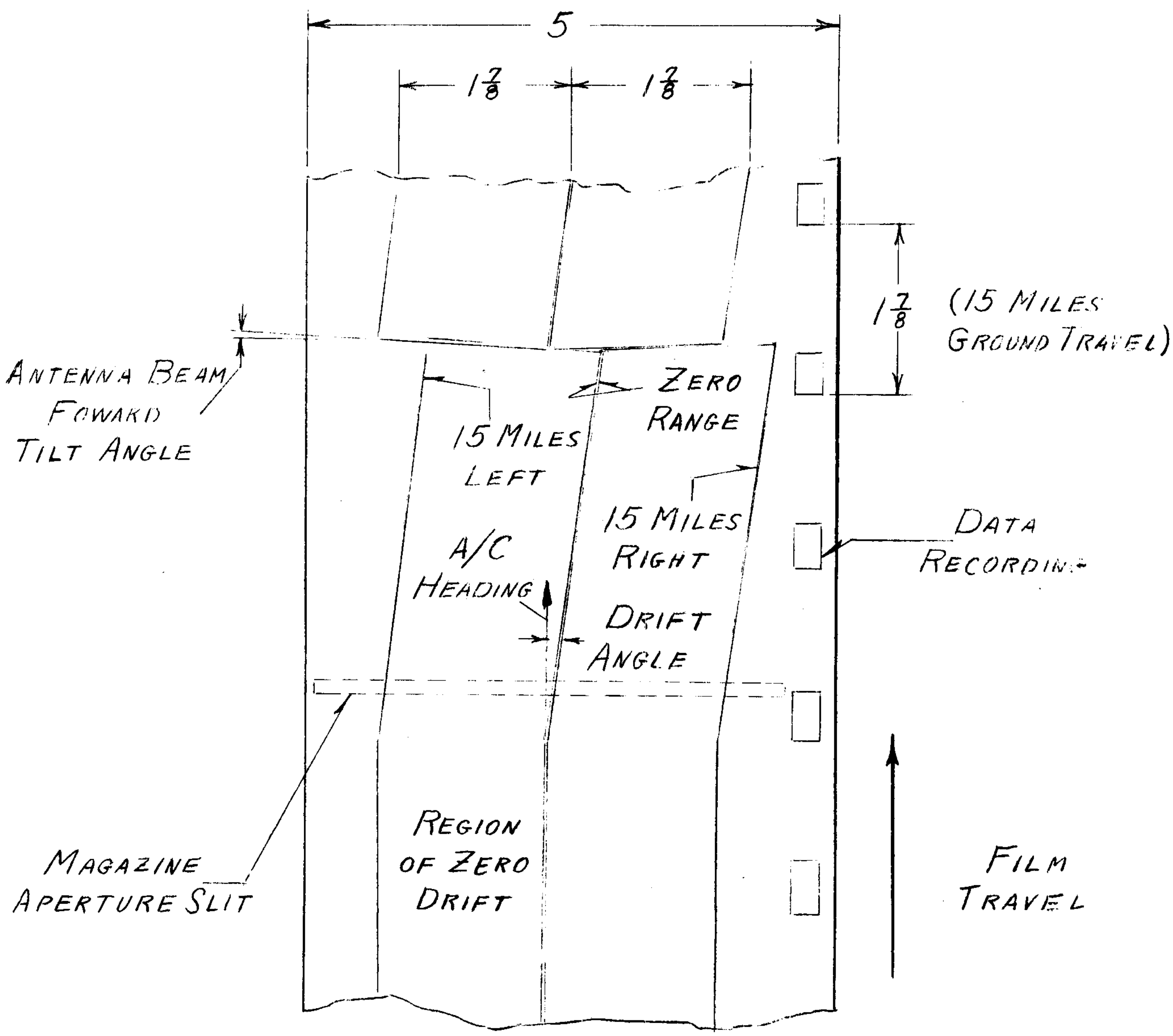

FIG. 1 FILM MAP GEOMETRY

the length of the ground range trace will be limited to about 3.25 inch yielding roughly 1000 line resolution, i.e. 90 ft. on a 15-mile range scale. Except for drift compensation the trace will be stationary on the CRT. High-voltage connection to the tube will be designed for operation in ambient pressures at least as low as 1.7 psi (50,000 ft. pressure altitude) as a design objective. This limit is adequate for most cockpit installations.

3.3.2.3 Signal Channel

The total receiver (the combination of i - f and video amplifiers) will be designed for a non-linear "compressed" transfer function as required for the best combination of small-signal sensitivity and large dynamic range. An approximate cube root characteristic seems more desirable than a logarithmic characteristic since such a shape would compensate for the cube-law CRT characteristic. This would result in the overall system unity gamma which the television industry has demonstrated to be very satisfactory for high-quality image reproduction.

The light meter problem is closely associated with the receiver-video combination. Receiver gain and CRT bias will be adjusted to produce predetermined light levels, as measured with a sensitive photocell, and will be maintained at these values by automatic control circuits. Such a procedure is required to maintain close system control essential for high-quality photographic results and to eliminate operator attention or interruption of the mapping process during flight.

3.3.2.4 Deflection System

A ground range hyperbolic sweep will be generated to cover 0-15 nautical miles (0-90,000 feet). Altitude may be set in over a range of zero to 70,000 feet either manually at the control panel or automatically through a synchro tie-in to an absolute altimeter. The altitude delay circuitry will be considerably redesigned from that used in the (XA-2) to provide delay accuracy comparable to the range mark accuracy. (See 3.3.2.6). Optimum hyperbolic sweep accuracy will be obtained through use of readily interchangeable plug-in units to be selected upon the basis of the altitude range for a given mission. This hyperbolic sweep will be coupled through stable deflection drivers to low-inductance CRT deflection yokes. "Striping" due to line voltage rapid fluctuations will be avoided by use of high-voltage supplies which incorporate built-in discharge tubes or other suitable instantaneous regulators.

3.3.2.5 Data Stabilization

Drift (or "crab") compensation will be provided to prevent map distortion resulting from departure of direction of travel from direction of heading. Ground speed and drift controls on the control panel or tie-in to a doppler system radar and computer such as the APN-79 or APN-81 will provide output voltages proportional to velocity in the heading direction and velocity normal to heading. The former "ground track" velocity will be used to control film rate. The latter "drift" velocity will be integrated to generate a slowly increasing CRT deflection component such that the zero ground range line will gradually move away from its centered position, as indicated on Figure 1. When the total accumulated drift becomes so large that the image is at the limit of the useful film region, this integrator will be dumped automatically and the process repeated. With 20° maximum drift angle and the anticipated film record geometry this dumping typically will occur at greater than 15-mile increments.

Pitch and yaw compensation are not proposed for a number of reasons. First, in aircraft equipped with modern improved autopilots purported deviations from a constant flight altitude are held to less than $\pm$ 1 degree at rates less than $\pm$ 0.25 degree/sec. in all three axes, roll, pitch and yaw. With such limited magnitudes "smearing" (lost resolution) and distortion resulting from these deviations are neglibible. Second, it is pertinent to note here that compensation of the display for much larger and/or more rapid pitch and yaw leads to unavoidable <u>very severe</u> striping of the picture. Experience has shown that striping is intolerable. The inevitable conclusion is that stable flight in the yaw and pitch axes is a "must" for effective side-look mapping and that pitch and yaw compensation in the recorder is neither necessary nor desirable.

3.3.2.6 <u>Range Marks</u>

One mile (6,000 feet) slant range marks will be provided with every fifth mark accentuated. The marks will be mixed with the video drive to the CRT each time the data chamber in the camera is flashed, i.e., once each 15 miles of travel. The range mark accuracy will be better than $\pm$ 0.5 percent.

3.3.3 Monitor Indicator

The monitor indicator will be a time-shared A-scope presenting two parallel A-traces which display the respective video returns from the right and left antennas. A 3-inch CRT will be used. The video drive, range sweeps, and high-voltage will be derived from the automatic recorder unit so that a normal A-scope picture will indicate normal operation of the complete equipment. In addition, a counter on the monitor panel will be operated by the film travel so that it will advance one count for every 15 miles of ground travel.

3.3.4 Control Panel

It is anticipated that the control panel will contain the following operation controls: off-standby-on switch, altitude, ground speed, drift angle, manual-automatic data selectors.

3.3.5 Alignment Panel

It is anticipated that the alignment panel will contain the following controls: test meter, meter selector switch, receiver gain, receiver tuning, and manual-AFC. These controls will be accessible during flight to permit initial adjustment after equipment warm-up, and to facilitate simple checks by the pilot in case of suspected malfunction.

3.4 Power Supply

The power supply unit will contain the low voltage regulated d-c supplies and a portion of the system control and relaying circuitry. It will also serve as a system junction box.

It is anticipated that four regulated d-c sources will be provided capable of supplying the following voltages with the stated current capacities:

+ 300v	200 ma.
+ 150v	200 ma.
+ 100v	200 ma.
- 300v	200 ma.

An unregulated supply of 400v, 400 ma. will be provided. It is proposed that the power supply unit utilize in general the same circuitry which is employed in the AN/APQ-56 (XA-2) power supply. However, in order to effect a weight reduction, certain changes in the unit will be made and certain others will be considered and will be incorporated if found feasible. The transformers will be redesigned for smaller size and weight and 3-phase operation. Metallic rectifiers will be used. Metallic rectifiers offer the following advantages over gas diodes: less heat dissipation, no filament transformer required, no tube sockets and clamps required. Also, an overall reduction in the size of the rectifiers themselves can be realized.

The system control circuitry will be similar to that used in the APQ-56 (XA-2). However, all relays associated entirely with the RT units including the overload and time delay relays will be removed from the power supply.

It is believed that by incorporating the changes outlined above the weight of the power supply can be reduced from the 45 pound weight of the APQ-56 (XA-2) power supply to 40 pounds in a volume of 1.3 cu. ft.

4. ENVIRONMENTAL TESTS

The equipment will be tested in the aircraft environment and any malfunctions to the equipment caused by its operating environment will be corrected. It is anticipated that complete MIL environmental tests will be run by Westinghouse on equipment of comparable design under existing U.S.A.F. contract AF 33(600)30545. Equipment supplied under this program will have the benefits of these environmental test results.

5. MAINTENANCE TOOLS AND TEST EQUIPMENT

Maintenance tools and test equipment for field maintenance of the radar mapping sets are listed in Appendix B.

6. SPARE PARTS

Spare parts for the Radar Mapping Sets for two (2) years operation will be supplied. A detailed list of spare parts, which have now been selected, is shown in Appendix C. It is estimated this list contains 90% of all spares items required. As the equipment design progresses additions to this list will be submitted.

7. EXTRA RECEIVER TRANSMITTERS

Work was started on July 25, 1955 on the design and fabrication of three Radar Mapping Sets (Dual Channel), AN/APQ-56 ( ), as proposed in Sections 2 through 7 of Westinghouse Proposal AAN-40037-C dated 22 September 1955. Later discussions with the customer altered the direction of effort to provide four (4) Single Channel Radar Mapping Systems as herein proposed. On the basis of the original proposal, six (6) Receiver-Transmitters, (two for each system) were released for manufacture. By the time the direction of effort had been altered, reducing the Receiver-Transmitters required from six (6) to four (4), parts for six (6) units had been ordered and fabrication had begun. Considering their status, and possible future requirements, agreement was reached between the customer and Westinghouse to complete manufacture and test of the two extra Receiver-Transmitters. Item 4 of this proposal applies to this work.

A P P E N D I X "A"

9 December 1955

RADAR MAPPING SET

This specification is derived from Exhibit WCLR-301 part of Contract AF-33(600)30545, revised to incorporate the requirements of a single-channel time-shared system.

1. SCOPE

1.1 This exhibit covers the general requirements of one type of Mapping Set designated as Radar Mapping Set.

1.1.1 This is a high resolution, side-looking radar which produces a continuous high quality strip map of an area up to 15 nautical miles each side of an aircraft in flight at altitudes up to 70,000 feet.

2. APPLICABLE DOCUMENTS

2.1 The following specifications, standards, drawings and publications of the issue in effect on the date of invitation for bids, shall form a part of this exhibit to the extent specified herein.

SPECIFICATIONS

Military

MIL-C-6781	Control Panel; Aircraft Equipment, Rack or Console Mounted.
JAN-J-641	Jacks, Telephone
MIL-W-5274	Wire, Electrical, Insulated, Aircraft
MIL-E-5400	Electronic Equipment, Aircraft, General Specifications for
MIL-E-7894	Electric Power, Aircraft Characteristics of
MIL-M-7969	Meters; Alternating Current, 400 Cycles, 115/200 Volt System, Aircraft General Specification For

MIL-R-8103	Radar Set AN/APN-81
MIL-M-8609	Motors, Direct Current, 28 Volt System, Aircraft, (General Specification For)
MIL-C-8384	Connectors, Electrical (Internal Type) and Accessories

STANDARDS

Military

MIL-STD-130	Identification Marking of U.S. Military Property
MS24123	Plate, Identification

Air Force-Navy Aeronautical

AN3102	Connectors - Electrical Receptacles, Box Mounting

DRAWINGS

U. S. Air Force

51C13643	CX-1331A/U Test Lead Set, Assembly

(Copies of specifications, standards, drawings and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

3. REQUIREMENTS

3.1 Components - One complete Radar Mapping Set shall consist of the following major components:

1 Each - Dual Antenna
1 Each - R F Head
1 Each - Modulator
1 Each - Adapter Box
1 Each - Recorder
1 Each - Control Panel
1 Each - Alignment Panel
1 Each - Monitor Indicator
1 Each - Power Supply
1 Each - Pressurizing Kit
1 Set - Interconnecting Plugs and Adapters

3.2 General - The requirements of Specification MIL-E-5400 are applicable as design objectives for this exhibit with the following additions or exceptions to the paragraphs of Specification MIL-E-5400 as identified by similarity of paragraph headings. Where the requirements of the general specification and this exhibit conflict, the requirements of this exhibit shall govern.

3.2.1 Connectors

3.2.1.1 Connectors for Voltmeter or Milliammeter Measurements. - Connectors for voltmeter or milliammeter measurements other than PJ-055B in accordance with Specification JAN-J-641 shall accommodate test prods in accordance with the requirements of Drawing 51C13643.

3.2.1.2 Connectors Wired In - Soldered electrical connectors shall not be painted or fungus treated. Resin deposits, however, shall be removed.

3.2.1.3 Internal connectors shall meet the functional requirements of MIL-C-8384.

3.2.2 Controls - Control panel lighting and pilot lamps of major components other than those in accordance with Specification MIL-C-6781 shall be provided with brilliance controls.

3.2.3 Finishes - Aluminum parts or chassis which need to be bonded or grounded shall not be lacquer finished on surfaces which provide bonding and grounding.

3.2.4 Marking and Identification.

3.2.4.1 Identification of Product - Equipment, assemblies, and parts shall be marked for identification in accordance with Standard MIL-STD-130.

3.2.4.2 The weight of major components shall be marked on three external surfaces of the components providing this weight exceeds 50 pounds.

3.2.4.3 Nameplates - Nameplates shall conform as closely as practicable to Standard MS24123.

3.2.5 Motors - Motors operating from d-c shall comply with the requirements of Specification MIL-M-8609 and motors operating from a-c shall comply with the requirements of Specification MIL-M-7969 insofar as the requirements do not conflict with those therein.

3.2.6 Meters (Electrical Indicating Instruments). - Only ruggedized meters shall be acceptable.

3.2.7 Wire (Hook-Up) - Wire in accordance with Specification MIL-W-5274 shall be used where high insulation resistance is dictated by circuit design.

3.2.8 Cooling - Particular attention in design shall be given to provide adequate means for cooling. Such cooling means shall be integrated in the design and shall be the simplest practical type consistent with the requirements.

3.2.9 Fungus Treatment - Fungus inert materials and parts shall be used to the greatest extent possible. Over-all spray or brushing shall not be used.

3.2.10 As a design objective the equipment shall have a minimum total operating life of 1000 hours with reasonable servicing and replacement of parts.

3.2.11 Maintenance Provisions - The equipment shall be so constructed that no damage to any component or any undue distortion to any structural parts shall be caused by placing any of the six sides of the equipment on a flat surface.

3.2.12 Service conditions (Electrical)

3.2.12.1 The equipment shall perform as specified herein when operated during the cruise-combat conditions from a Type II system in accordance with Specification MIL-E-7894.

3.2.12.2 Where d-c power is required, the equipment shall perform as specified herein over the range of 25 to 29 volts. Where only a small load exists the d-c source shall not be used, and the load may be supplied by individual rectifiers where this will result in a reduction in weight.

3.2.12.3 Power Ratings - As a design objective the power required by the equipment shall not exceed the following:

a) 2800 - volt-amperes from the 380 to 420 cps 3 phase source.

b) 100-watts for the d-c source.

3.2.13 Service Conditions (Vibration) - The Radar Set shall be capable of withstanding the vibration encountered in jet aircraft.

3.2.14 Stability - As a design objective the equipment shall operate with specified performance for at least 15 hours, continuously or intermittently, without adjustment of any controls which are not accessible during flight. During the first 6 hours of the 15 hour period, no adjustment of any control shall be anticipated.

3.3 Design of Receiver-Transmitter - The Receiver-Transmitter shall consist of the following items: magnetron, modulator, r-f switch, duplexer, local oscillator, mixer, IF amplifiers, second detector, video amplifiers, and essential circuitry. The Receiver-Transmitter will comprise the following units: R F head, modulator, and adapter box.

3.3.1 Size and Weight - The size and weight of the Receiver-Transmitter shall be as small as practicable consistent with the required performance and life. Every effort shall be made to use materials of light weight and to employ methods of design and construction which effect minimum size and weight. The weight of the Receiver-Transmitter shall not exceed 150 lbs. As a design objective the Receiver-Transmitter shall be so constructed that no one package shall weigh over 100 lbs.

3.3.2 Cooling - The components in the Receiver-Transmitter shall be adequately air cooled with an a-c operated motor driven blower.

3.3.3 Pressurizing - Adequate pressurizing shall be provided to permit full power, trouble-free operation of the Receiver-Transmitter units at any altitude below 70,000 feet.

3.3.4 Frequency - The Receiver-Transmitter units shall be designed to operate within the scatter band of 34512 to 35208 megacycles.

3.3.5 Power Output - The transmitter section of the Receiver-Transmitter units shall deliver peak RF power of approximately 100 KW commensurate with the magnetron ratings.

3.3.6 Pulse Duration - The pulse duration (width) of the transmitted signals shall not exceed 0.1 microsecond.

3.3.7 Pulse Time jitter - Pulse time jitter shall be held to a minimum consistent with the present state of the art.

3.3.8 Pulse Repetition Frequency - The pulse repetition frequency shall be the maximum consistent with magnetron peak power output and radar range requirements.

3.3.9 Receiver Signal Mixer - The receiver shall employ either a balanced signal mixer using matched crystal pairs, or other devices providing improved characteristics.

3.3.10 Receiver Noise Figure - The receiver noise figure shall not exceed 16 db.

3.3.11 Automatic Gain Control - An automatic gain control circuit shall be employed to stabilize the receiver gain during long periods of unattended operation.

3.3.12 Automatic Frequency Control - Automatic control of receiver tuning capable of following frequency changes of the magnetron as closely as the state of the art permits, shall be provided.

3.3.13 Intermediate Frequency - The selection of an intermediate amplifier frequency shall be at the discretion of the contractor.

3.3.14 I. F. Amplifier, Bandwidth - Intermediate frequency amplifier bandwidth shall be determined by the contractor.

3.3.15 Receiver Dynamic Range - A non-linear receiver characteristic shall be employed to provide an extended dynamic range for the complete receiver-recorder combination.

3.3.16 Uniformity of power handling capabilities - The receiver-transmitter unit, its associated waveguide and connectors shall be capable of handling the maximum RF power specified in 3.3.5, regardless of maladjustment or component ageing.

3.3.17 R F Switching - The receiver-transmitter shall contain provisions for transmitting and receiving energy alternately from the two radiating elements of the dual antenna. The switching rate shall be consistent with uniform coverage of the ground on both sides of the aircraft.

3.4 Radar data recorder, design - The data recorder shall include all operating controls, a type "A" monitor oscilloscope, an intensity modulated display cathode ray tube, and the necessary photographic recording system. The radar data recorder shall comprise the following units: recorder, control panel, alignment panel, and monitor indicator.

3.4.1 Function - The principal function of the data recorder shall be to produce a photographic record of the radar data received from both radiating elements of the dual antenna. These recorded data shall constitute ground maps in cartesian coordinates.

3.4.2 Recording Technique - The video return shall be used to intensity modulate true ground range sweeps on a high resolution cathode ray tube. A recording camera shall be focused on the trace with the film moved smoothly at a rate proportional to a function of aircraft true ground velocity. The signals shall be switched in synchronism with the R F switching so that the return from the left radiating element appears on the left side of the film record and the return from the right radiating element is recorded on the right side of the film.

3.4.3 Control and Alignment Panels - The operator's panels shall contain all switches and adjustments required for operation of the radar set. A design objective shall be simplification of the panels and all controls not actually used in flight shall be recessed.

3.4.3.1 Film Velocity Control.

3.4.3.1.1 Manual - A dial calibrated from 250 to 100 knots shall be provided on the panel to manually adjust film velocity for various aircraft true ground velocities.

3.4.3.1.2 Automatic - Provisions shall also be included for automatically feeding ground speed information to the recorder from a doppler system radar and computer, such as the AN/APN-79 or AN/APN-81.

3.4.3.2 Frame Counter - A veeder-root type of counter shall be displayed to indicate the amount of film used.

3.4.3.3 Current Monitors - Provisions shall be included for monitoring receiver crystal currents, AFC crystal currents and magnetron currents of the receiver-transmitter.

3.4.3.4 Non-interruption of Sweep - Recorder circuitry shall be so arranged that in-flight level setting controls may be adjusted without interruption of the mapping process.

3.4.3.5 Altitude Delay - Control of sweep start for periods of time proportional to altitudes from zero to 70,000 feet shall be provided by means of a calibrated dial on the control panel. Provision for maintaining sweep accuracy over the specified altitude range is also required. Interchangeable plug-in units may be used to obtain optimum display accuracy over the specified range of altitude.

3.4.4 Cathode-ray Tube, display - Rectangular, square or round cathode-ray tube may be employed in the recorder at the discretion of the contractor. Tube configuration shall be determined on the basis of the most efficient presentation of data commensurate with minimum overall recorder size and compatible with the required functions. The cathode-ray tube resolution shall be equivalent to a minimum of 1000 lines per diameter.

3.4.5 Monitor A-Scope - The return from both right and left side of the dual antenna shall be displayed simultaneoulsly on the monitor oscilloscope. High speed electronic switching to display both returns on a single cathode-ray tube, one cathode-ray tube with two electron guns or two separate tubes may be employed in the presentation. Manual switching to permit viewing of first one return and then the other shall not be acceptable.

3.4.6 Drift Stabilization - Stabilization of data in the recorder shall compensate for aircraft drift angle (crab) error to ± 20 degrees with an accuracy of ± 1 degree. Provisions shall also be included for automatically feeding drift information to the recorder from a doppler system radar and computer such as the AN/APN-81 or AN/APN-79. Constant heading tactics may be assumed in the design of the drift stabilization circuitry.

3.4.7 Recorder Film - Commercially available black and white film, five inches in width shall be used in the recorder.

3.4.8 Size and Weight - The size and weight of the Radar Data Recorder units shall be as small as possible, and not to exceed 100 pounds as a design objective.

3.4.9 Photographic Record Format - The recording unit shall be so arranged that the photographic record shows the following format:

3.4.9.1 Exposure Positioning - Radar data obtained from the left side of the dual antenna shall be displayed on the left side of the printed photographic record. The converse shall exist for the right side. The two simultaneously exposed photographs shall be positioned side by side, rather than sequentially, on the final print.

3.4.9.2 Aircraft Position - Aircraft position shall be considered to be midway between the left and right side recordings.

3.4.9.3 Data Chamber - At even increments of film travel the following information shall be displayed in the data chamber.

3.4.9.3.1 Time - The time the photographic record is made shall be identified by a 24 hour clock equipped with hour, minute and second hands.

3.4.9.3.2 Heading - Aircraft heading at the time of exposure shall be indicated by means of a compass repeater or other type of instrument.

3.4.9.3.3. Frame Number - A Veeder-Root type of frame counter shall be displayed to assist in radar photograph identification. This counter shall be synchronized with a similar instrument visible to the operator.

3.4.10 Exposure Size - The recording camera shall produce two simultaneous side by side exposures with the image of the cathode ray tube trace having a length of approximately 1 7/8 inches.

3.4.11 Range Marks - Circuitry shall be included to provide a reference mark for each 6000 feet of slant range, with an accuracy of $\pm$ 0.5 percent. Every fifth mark shall be accentuated. The range marks shall be applied momentarily each time the data chamber is recorded.

3.4.12 Exposure Meter - Included in the recorder shall be an accurate means for establishing the required cathode-ray tube trace intensity for recording under various conditions.

3.5 Design of Dual Antenna

3.5.1 Size and Weight - The antenna assembly shall be designed for minimum size and weight consistent with the degree of rigidity required in this type of installation. The weight of the antenna shall not exceed 120 pounds as a design objective.

3.5.2 Description - The antenna shall consist of two 15 foot linear arrays on a common base, with slotted waveguide feed and suitable lenses for beam shaping. Flanges and waveguide shall be compatible with the remainder of the system.

3.5.3 Construction - Extrusion type construction shall be employed wherever practicable.

3.5.4 Mounting - The antenna shall be designed for mounting in an unpressurized compartment of a reconnaissance aircraft. A two point mounting shall be utilized to suspend the antenna from the air frame such that flexing of the airframe will not cause flexing of the antenna.

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3.5.5 Pressurizing - Each antenna assembly shall be pressurized as necessary to permit the utilization of the maximum RF power specified in 3.3.5, at any altitude below 70,000 feet.

3.5.6 Direction of Peak Intensity - The direction of peak intensity of each antenna pattern shall be 88 degrees ± 2 degrees with respect to the longitudinal axis of the antenna.

3.5.7 Radiation pattern - vertical plane - The pattern of each antenna in the vertical plane shall be that necessary to obtain uniform response from similar targets at any range between 2 and 15 nautical miles, from an altitude of 62,500 feet. A maximum of 1.5 db variation from the optimum curve shall be held as a design objective.

3.5.8 Radiation Pattern - Horizontal Plane - The pattern of each antenna in the horizontal plane shall not be more than 0.13 degree in beam width at the half power points. Minor lobes shall be at least 12 db down compared to the peak intensity of the overall radiation pattern. It shall be an objective of this design to further reduce the side lobe amplitude.

3.5.9 Voltage standing wave ratio - The VSWR of each antenna radiating element together with the interconnecting waveguide shall not exceed 1.2:1 throughout the specified frequency range, when the antenna is radiating into free space.

3.6 Design, Power Supply - The power supply shall furnish all low voltage dc requirements for the receiver-transmitter and recorder units. It shall also contain primary power control relays, delay and overload relays, voltage regulating equipment, and other circuitry at the discretion of the contractor.

3.6.1 Size and Weight - The power supply shall be as small and light in weight as practicable, consistent with its several functions. The total weight of the unit shall not exceed 40 pounds.

3.7 Design of Pressurizing Kit - The pressurizing kit shall supply all of the pressurizing required for operation of the system.

3.7.1 Type of System - The pressurizing systems may take the form of a closed system employing sulphur hexafluoride or similar gas, or an open system in which uncontaminated and dehydrated air is compressed by means of a conventional pump. In either case the system shall be capable of maintaining the required pressure for a period of 15 hours at an altitude of 70,000 feet.

FACTORY LABOR AND MATERIALS

FACTORY MATERIAL

COMPONENT	Estimated Direct Cost Each System	ITEM 1	2	3	4
Recorder	29,700	89,100	29,700	29,700	29,700
Power Supply	1,691	5,073	1,691	1,691	1,691
Modulator	5,918	17,754	5,918	5,918	5,918
R. F. Head	11,162	33,486	11,162	11,162	11,162
Adapter	609	1,827	609	609	609
Pressure System	2,216	6,648	2,216	2,216	2,216
Antenna	13,036	39,108	-	-	-
Cabling	742	-	-	742	742
Tools		4,100	-	200	-
Shop Development		3,200	-	-	-
Test Equipment		28,000	-	-	-
	TOTAL	$228,296	$51,296	$52,238	$52,038

FACTORY LABOR

COMPONENT	Estimated Factory Labor (Each) Set Up	Run Time	ITEM 1	2	3	4
Recorder	1489	629	3,376	629	629	629
Power Supply	497	210	1,127	210	210	210
Modulator	526	144	958	144	144	144
R-F Head	821	523	2,390	523	523	523
Adapter	89	41	212	41	41	41
Pressure System		4	12	4	4	4
Antenna	219	676	2,247	-	-	-
Cabling	2	308	-	-	310	308
		TOTAL	10,322	1,551	1,861	1,859

ENGINEERING LABOR AND MATERIAL

ITEM 1

LABOR:

Surveillance Radar	20,900 Hours	@ 3.35	70,015
Engineering Laboratory	2,200	@ 1.91	4,202
Flight Engineering	3,370	@ 2.70	9,099
Technical Publications	1,100	@ 2.49	2,739
Components Engineering	1,100	@ 2.64	2,904
	28,690 Hours		$88,959
	7	Average Wage Rate	$3.10

Drafting 9,370 Hours @ 2.35

MATERIAL: $17,000

ITEM 2

LABOR:

Surveillance Radar 1,000 Hours @ 3.35

MATERIAL: $2,000

ITEM 3

LABOR:

Surveillance Radar 200 Hours @ 3.35

ITEM 4

LABOR:

Surveillance Radar 200 Hours @ 3.35